and 11 inches at Omaha, Nebr. On the 22d there were 6 inches at Albany, N. Y.; 20 inches at St. Paul, Minn.; none at Dubuque and Davenport, Iowa; 15 inches at La Crosse, Wis.; 28 inches at Williston, N. Dak.; 23 inches at Yankton, S. Dak.; 7.5 inches at Omaha, Nebr. On the 29th the reported thickness of ice in inches was as follows:

Hudson River.—Albany, N. Y., 8.

Upper Mississippi River.—St. Paul, Minn., 20.5; La Crosse, Wis., 22; Dubuque, Iowa, 10; Davenport, Iowa, 8; Keokuk, Iowa, 7.5; Hannibal, Mo., 8.

Upper Missouri River.—Williston, N. Dak., 24; Bismarck, N. Dak., 30; Pierre, S. Dak., 25; Yankton, S. Dak., 21; Sioux City, Iowa, 18; Omaha, Nebr., 15; Kansas City, Mo., 6.

Platte River.—North Platte, Nebr., 16.

Lake Superior.—Duluth, Minn., 21; Sault Ste. Marie, Mich., 19.

Lake Michigan.—Green Bay, Wis., 18; Chicago, Ill., 5; Grand Haven, Mich., 2.

Lake Huron.—Alpena, Mich., 4.

Lake Erie.—Toledo, Ohio, 4; Sandusky, Ohio, 4.5; Cleveland, Ohio, 3; Erie, Pa., 2.5; Buffalo, N. Y., 2.

Lake Ontario.—Oswego, N. Y., 4.

The following special reports have also been collected:

Allegany River.—Pittsburg, Pa., 27th to 31st, floating ice.

Detroit River.—Detroit, Mich., 7th and 8th, closed by ice in morning, but soon opened by ferry boats.

Hudson River.—Albany, N. Y., 1st, floating ice; 3d, frozen from shore to shore.

Mississippi River.—Dubuque, Iowa, 8th, frozen over; 17th, channel partly open, but full of floating ice; 18th, only a small quantity of floating ice; 21st, open at Eagle Point, a few miles north, and in front of this place below the bridge; 22d; open from Eagle Point to this place; 24th, again frozen. Fort Madison, Iowa, 23d, frozen during the night. Hannibal, Mo., 25th, frozen. Le Claire, Iowa, 20th, ice broken up; 22d, frozen again.

Missouri River.—Hermann, Mo., 8th and 10th, floating ice; 11th, gorged; 24th, heavy floating ice; 25th, frozen.

Ohio River.—Marietta, Ohio, 28th to 31st, floating ice. Parkersburg, W. Va., 29th to 31st, running ice. Wheeling, W. Va., 13th, floating ice; 27th to 31st, floating ice.

Lake Erie.—Cleveland, Ohio, 12th, 25th to 31st, floating ice.

Lake Huron.—Port Huron, Mich., 1st to 12th, 24th, 25th, 30th, and 31st, floating ice; 25th, the Black River frozen over.

Lake Superior.—Marquette, Mich., 25th, harbor frozen over.

Wisconsin.—Rock River, ice 11 inches thick. Rock Lake, ice 14 inches thick. Hartford, ice 14 inches thick, the ground frozen 4 inches deep.

Minnesota.—Excel, Thief River, at the end of the month, ice 28 inches thick. Minneapolis, ice 22 inches thick on the lake. Marfield, ice 30 inches thick on lakes and ponds. Blooming Prairie, ice 2 feet thick on Cedar River; Willmar, ice 28 inches thick on lakes.

OBSERVATIONS ON THE GREAT LAKES.

Owing to the closing of navigation on the Great Lakes during the winter season the Weather Bureau has received reports for the month of January from no vessels and from only 10 U. S. Life-Saving stations.

SURFACE CURRENTS.

The collection of floating bottles for the determination of currents is necessarily interfered with by the presence of ice, but the drift of the ice itself should be noted by those interested in this class of observations. A discussion by Prof. M. W. Harrington of the results of the work done by the Weather Bureau in 1892 and 1893 has been published in an official circular, Bulletin B, from which the following extracts are taken:

The investigations of this paper relate to the season of navigation and the currents that appear on the maps are practically the currents of the summer season. It is entirely possible that the currents of the other seasons would show some variations.

A. The Lakes all have an outflow, and there must be a general motion of the water toward this outflow; the speed of this body current is very slight.

B. The winds have a great effect on the currents, and the most frequent winds on the Great Lakes are shown in the proper tables, from which it appears that 30 per cent are from the southwest, 22 per cent from the west, 14 per cent from the northwest, 10 per cent from the northeast, 14 per cent from the south, 5 per cent from the southeast, 3 per cent from the north, and 1 per cent from the east. The general resultant wind during the summer months is westerly, but at a few stations it is easterly.

C. The return currents.—It will be observed that, in the case of three of the lakes, the main currents hug one shore. In the case of Lake Superior, it is the southern shore; in the case of Lake Michigan, it is the eastern shore; and in that of Lake Huron, it is the western shore. In the case of Lake Erie and Lake Ontario this phenomenon does not appear so plainly. This feature can be explained by the two sorts of currents already mentioned, combined with the lay of the lakes, as to the prevailing direction of the wind and the position of the outlet. In the case of Lake Superior the outlet is on the southern side. In the case of Lake Michigan the readiest access to the outlet is along the eastern shore, the access from other directions being barred by the group of islands near the northern end of the lake. In the case of Lake Huron the outlet is on the western side, as are also the inlets of the lake.

In any case the drive of the water from one end of the lake to the other necessitates more or less a return current, providing the outlet is not sufficiently large to allow this water to pass through. In the Great Lakes the outlets are relatively small, so that in all these cases there must be return currents. Such currents will combine with the direct ones to make a large general whirl in the lake if the latter is sufficiently broad (lakes Superior and Huron), or lies across the wind (lakes Huron and Michigan). If the lake has its long axis in the direction of the wind (lakes Erie and Ontario), the return currents will break up into smaller whirls along the great pockets of the coast on either side of the general current. Around groups of islands a smaller return current, or a distinct swirl, will be set up. All these cases are illustrated in the detailed discussion which follows.

D. Surf motion.—A wave which is not breaking does not necessarily carry forward a body floating on its surface, but so soon as it breaks, the surf on the crest of the wave will carry with it any body which happens to be floating in it. The result of this is that while a body is outside of the surf it is carried on by the general drift of the water. So soon as it comes within the surf it advances more or less rapidly in the direction in which the surf is moving. Now, the surf occurs generally in shallow water and seeks the shore. Therefore, the bottle papers will be found to have a decided tendency shoreward whenever they come within its vicinity, and especially so when the water is shallow. This may be the general shore, or it may be the shore of islands within the lake. Moreover, there is a very curious phenomenon occasionally appearing on the maps, which can also be accounted for by this surf motion. This is the tendency of the bottles to pass into deep bays and along their length, and to be lodged on the shore somewhere near the bottom of the bay. This is undoubtedly due to surf motion. Generally speaking, the waves in these long bays move up the bay, and have more or less surf. The body floating on them will also move up the bay, and its tendency will be to pass up the entire length of the bay, or nearly so.

The attention of the Weather Bureau will be directed in the season of 1894 more especially to the recovery of the bottles which have been floated but not yet found. It appears, as already stated, that probably not 10 per cent of the bottles have been recovered. It will be comparatively easy to search the shores with reference to recovering others, and it is hoped that a large number can be added to throw further light on the character of the currents of the Great Lakes. Navigators of the Lakes, fishermen, residents on the shores, and others who have occasion to visit the shore are earnestly requested to make every effort to recover what bottles are lying there, and to return to the Weather Bureau the inclosed paper, with the proper memoranda.

SUNSHINE AND CLOUDINESS.

The quantity of sunshine received by the atmosphere above the cloud layer, on any given day or month, is constant from year to year, and the heat attending this sunshine is sensibly constant, although there are some indications of a barely appreciable variation in this heat associated with the condition of the sun's surface. On the other hand, at the surface of the earth the distribution of sunshine (and therefore, of the resulting heat, ascending currents of air, winds, evaporation, the growth of plants, and other important effects) depends mostly upon the distribution of cloudiness.

Cloudiness.—The number of clear and cloudy days and the average cloudiness between sunrise and sunset are given for each Weather Bureau station in Table I. These means are based upon personal observations made during the day sufficiently often to secure a correct average cloudiness. The complements of the estimated percentages give the observer's estimated duration of sunshine, and these numbers are given in the last column of Table IV as supplementary to the registered duration, in the preceding column. The close accord of these numbers, in most cases, is very satisfactory.

The occasional large discordance between the monthly sunshine as estimated by the observers and as registered by the instruments shows how impossible it is for personal estimates to compete with continuous self-registers.

Sunshine.—At the present time an instrumental record of the amount of sunshine is kept at 15 stations by means of the "photographic sunshine recorder," and at 19 stations an equivalent record is kept by means of the "thermographic sunshine recorder." A description of these instruments and the method of dealing with the record is given on a subsequent page. The results of the observations for January, 1894, are given in Table IV. This table shows the actual sunshine received, on the average, for any hour of local mean time during the month; it is recorded as a percentage of the greatest possible amount of sunshine; for instance, the sun might possibly always shine during the whole hour ending at 1 p. m., whereas, at Baltimore, Md., it has, on the average, been cloudy 32 per cent of this hour, so that only 68 per cent of full sunshine has been received. Again, at the time of sunrise, between 7 and 8 a. m., during January, Baltimore records 13 per cent of sunshine, which means not 13 per cent of the thirty-one whole hours between 7 and 8 a. m., but 13 per cent of that portion of these hours during which the sun was above the visible horizon of that station; the remaining 87 per cent was cut off by clouds and fog. On the average both kinds of self-registers agree in giving 5.5 per cent more sunshine than the personal estimates by the observer.

The stations recording the largest percentage of sunshine between 11 a. m. and 1 p. m. are Colorado Springs, Colo., 83.5; Denver, Colo., 82.5; Key West, Fla., 81; San Diego, Cal., 89; Santa Fe, N. Mex., 83.5. Those having the least are Cleveland, Ohio, 39; Portland, Oreg., 23.5; Galveston, Tex., 41.5.

The next to the last column of Table IV gives the general average sunshine for the whole month for all hours of daylight; the highest percentages are San Diego, Cal., 84; Santa Fe, N. Mex., 79. The lowest averages are Portland, Oreg., 19; Cleveland, Ohio, 33; Buffalo, N. Y., 36; Galveston, Tex., 40. The low average for Portland, Oreg., is, of course, in keeping with the cloudiness of its rainy season.

NOTES BY THE EDITOR.

ELASTIC SUSPENSION FOR INSTRUMENTS.

Over fifty years ago Prof. G. B. Airy, Director of the Royal Observatory at Greenwich, desired to establish a shallow dish of mercury so that the pure reflecting surface of the liquid could be used for astronomical observations without being subject to the annoying tremors that ran over this surface whenever wagons, railroad trains, or even human footsteps jarred the earth around the pier on which it stood. He achieved perfect success by suspending the dish of mercury by a number of elastic springs. No matter how much the pier and, therefore, the upper ends of these springs were jarred, the minute vibrations did not run down through the springs to the basin of mercury, but were completely broken up on their way. In 1889 the present editor desired to support the Richard barograph on the U. S. S. *Pensacola* in such a manner that it should be free from all the effects of the jarring due to the engines and screw as well as from the effects of the rolling and pitching of the vessel. This again was accomplished perfectly by setting the instrument on a small shelf that hung suspended by long coiled springs at the four corners.

The "Washington State Weather Reporter," published by the State Weather Service at Seattle, describes the application of this principle to the suspension of maximum and minimum thermometers. Prof. L. P. Venen, of Vashon College, is the inventor of this method, which is described as follows: A rather heavy block of wood is suspended by a thick spiral spring from the ceiling of the ordinary thermometer shelter; one or more elastic cords are stretched from the block to the sides of the shelter, and thus keep the block from swinging with the wind; the maximum and minimum and other thermometers are fastened on the block and can, therefore, receive no violent, injurious shock from the outside; they are even safe from the slight jars due to the wind or other influences by means of which the index of the minimum thermometer is very apt to slip down too low.

Doubtless other applications of this method of elastic suspension will occur to meteorological observers. Its principle is, of course, the same as the application of springs to the axles of carriages and railroad cars, or of rubber tires to the wheels of cabs and bicycles.

THE RELIABILITY OF THE RAIN GAUGE.

In the winter season observers frequently report that the wind has blown too severely during a snowstorm to allow of accurate measurement; by this we are to understand one of two things, either the snow has been drifted so much that the observer can not make a satisfactory estimate of its average depth over the country in his neighborhood, or else that he has observed the wind carrying the snow past his gauge to such an extent that he can not consider the amount caught in his gauge as a fair indication of what fell, or of what would have been caught if there had been no wind. This phenomenon of drift and this deficiency in the catch of the rain gauge are matters that trouble not only the measurement of snow but of rainfall on all occasions; the rain gauge is subject to a very appreciable error, which has always the nature of a deficit, and which increases with the strength of the wind and the fineness of the rain. It seems a very simple matter to determine the quantity of rainfall by setting a simple cylinder or a pail or tub out in the open field and measuring the depth of water that falls therein. But if the gauge is in an open place fully exposed to every wind it will catch less rain than if it is artificially sheltered from the wind while standing in the same spot; if, on the other hand, the gauge is moved to a sheltered spot, it is liable to catch an erroneous rainfall, sometimes larger and sometimes smaller, depending on the location and heights of the buildings that shelter the spot. The true problem of the meteorological observer is to put his gauge in an open place, free from the influence of all buildings and trees, and yet determine the true rainfall at that spot free from the influence of the eddies produced by the wind at the mouth of his gauge. There is probably no error in the catch when it rains during a calm, but if the wind is blowing while the rain or snow is falling, then the gauge itself acts as an obstacle to the wind; the air that flows around it and above it, but close to it, moves faster than that a foot away from it; the snow flakes and finer particles of water that go into the gauge in one eddy come out on another. Some means must be devised to break up all eddies at the mouth of the gauge, or, failing that, we must have some method of applying a numerical correction.

Several instrumental methods have been adopted for preventing or diminishing the wind effect: *First*, about 1853, or earlier, Prof. Joseph Henry recommended to the Smithsonian observers a shielded gauge which is simply an ordinary cylindrical gauge having a horizontal, circular plate of tin 4 or 5 inches wide soldered to it an inch below the mouth of the gauge. By this means the disturbing eddies are kept principally beneath the flat rim, and, therefore, do no harm at the mouth of the gauge. *Second*, in 1878 Prof. Nipher, of St. Louis, described his form of shielded gauge in which the tin plate is replaced by an umbelliform screen made of wire gauze; the gauze sufficiently breaks up the wind eddies while it greatly diminishes the spattering. Nipher's experiment showed that gauges at the height of 118 feet above the ground caught nearly the same as those at the ground. *Third*, in 1885 Boernstein devised a protected gauge, which is an ordinary gauge surrounded at a distance of a few feet by a separate fence or screen whose top may be a little above the top of the gauge; this protecting fence, therefore, diminishes the wind at the mouth of the gauge without introducing new and injurious eddies. Roofs of buildings are occasionally built slanting inwards instead of outwards, or sometimes the walls of the buildings rise several feet above the surface of the roof; in such cases a gauge placed near the center of the roof is protected against the violence of the wind and catches more than it would if raised a few feet higher above this protection. *Fourth*, the so-called pit gauge as first used in England; in this method a shallow pit is dug, from 3 to 6 feet in diameter, in the midst of an open field, and the gauge is set in the center so that its mouth shall be on a level with the surrounding field while the spatter is diminished in proportion to the depth of the pit.

As the wind increases rapidly with the elevation above the ground, therefore, gauges placed at great heights will catch less rain or snow than those at low elevations. The amount of this deficit is known quite accurately from many years of observations, a summary of which has been published by the